“Landfills Last” Solid Waste Master Plan Review:

Preliminary Findings

Prepared by:

James Goldstein

Tellus Institute

Boston, MA

Solid Waste Advisory Committee

Massachusetts Department of Environmental Protection

Boston, MA

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TELLUS INSTITUTE

for a Great Transition

Context: New SW Master Plan

- Will lay the groundwork for shifting to a materials management framework that places greater emphasis on reducing waste during the production process.
- Envisions a “landfills last” approach as serving as an economic plan and vision as well as a waste reduction and environmental protection plan.

Context: Key External Drivers

- Climate Change
- Energy Crisis
- Natural Resource Depletion and Ecosystem Services Degradation
- Rise of Commodity Prices

Scope of Project

- Summarize existing studies comparing lifecycle environmental and economic impacts of:
  - source reduction and materials reuse, recycling, and composting;
  - alternative technologies such as gasification, pyrolysis, and anaerobic digestion; and
  - disposal in municipal waste combustors and landfills.
- Apply study results to MA data to explore alternative future vision for materials management in terms of environmental and economic benefits.
  - Vision should incorporate recommendations for how various options fit together to form a cost-effective materials management system that maximizes resource and economic values of materials formerly viewed as wastes.

Alternative Technologies: Gasification Profile

- **Gasification**: Thermal conversion of organic carbon-based materials with internally produced heat, typically at 1,400 - 2,500ºF, in limited supply of oxygen. Generates synthetic gases that can produce liquid fuels for electricity production.
- **Commercially Operating Facility in the United States**: No
- **Largest Facility**: Tokyo, Japan; facility can process 180 TPD of MSW
- **Net Energy Generated**: <400 to >900 kWh per ton MSW. Average heating value of feedstock is 3,870 Btu/lb.

Alternative Technologies: Pyrolysis Profile

- **Pyrolysis**: Decomposition or transformation of waste by external heat source (syngas or other), typically 750 - 1,500º F. Organic materials “cooked” with no air or oxygen present; no burning takes place. Higher temperatures produce gaseous byproducts, and lower temperatures produce more liquid pyrolysis oils.
- **Commercially Operating Facility in the United States**: No
- **Largest Facility**: Hamm-Uentrop, Germany; facility can process 175 TPD of MSW
- **Net Energy Generated**: < 700 kWh per ton of waste processed. Average heating value of feedstock is 3,660 Btu/pound.

Alternative Technologies: Anaerobic Digestion Profile

- **Anaerobic Digestion**: Biodegradable materials converted through a series of biological and chemical reactions into methane and carbon dioxide (CO2). Produces biogas, which can be used on-site to generate electricity and heat or as boiler fuel.
- **Commercially Operating Facility in the United States**: Not for MSW. U.S. facilities process only agricultural feedstocks; energy produced used on farms. Many int'l commercial facilities.
- **Largest Facility**: Barcelona, Spain; facility can process 1,000 TPD of MSW.
- **Net Energy Generated**: Biogas yield averages 4,300 standard cubic feet (or 756 kWh) per ton of feedstock.

Capital & Operating Costs of Alternative Technologies

- Gasification
  - $146,000 to $181,000 per TPD of installed capacity
  - Approximately $57-65 per ton of waste processed.
- Pyrolysis
  - NA
  - NA
- Anaerobic Digestion
  - 1 MW (~10,000 ton) facility estimated to cost $4.7 - $6.2 million
  - 1 MW facility estimated to cost $155,000 per year

Preliminary Findings: Alternative Technologies (1 of 3)

- **Pyrolysis** and **gasification** are potentially viable conversion technologies, though they are not well developed for processing high volumes of MSW to produce energy at the current time.
- No commercial gasification or pyrolysis facilities are processing MSW in the United States.
- Limited operational data available from other facilities around the world.
- Like incineration, pyrolysis and gasification can effectively reduce the volume of MSW. However, the energy recovery step, which is championed by technology suppliers, has yet to perform reliably when processing MSW at a commercial scale.

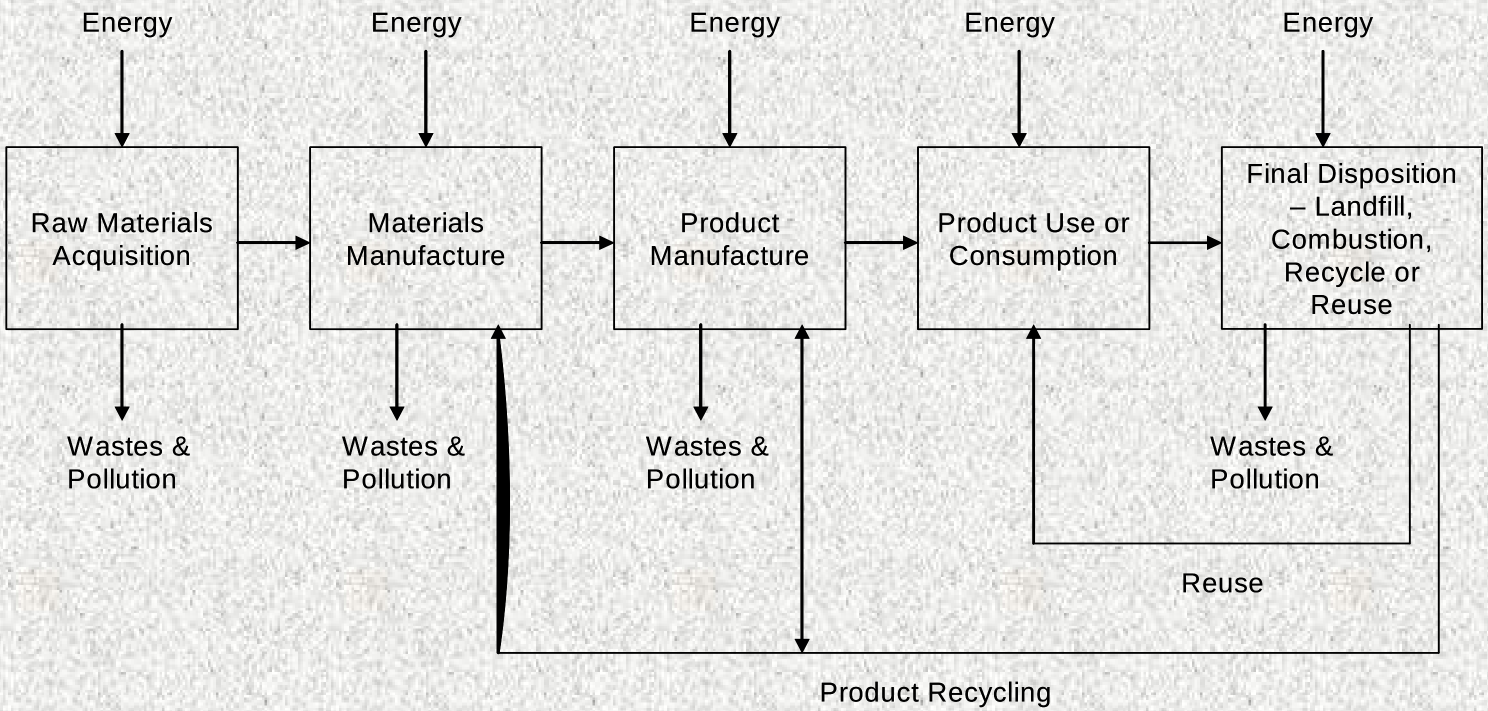
Preliminary Findings: Alternative Technologies (2 of 3)

- Some literature suggests pyrolysis and gasification may undermine recycling programs, as the need for a steady waste stream with high fuel value may compete with recycling.
- These facilities are highly capital-intensive and thus require long-term investments (and often contracts), which may limit flexibility to adopt alternative waste management options in the future.

Preliminary Findings: Alternative Technologies (3 of 3)

- **Anaerobic digestion** receives positive reviews because it is generally compatible with recycling programs, and the technology poses fewer risks to the environment and human health.
- In Europe, 87 anaerobic digestion plants are processing MSW, and the technology has been introduced in the U.S to process agricultural waste and generate electricity on dairy farms.
- Operational data on anaerobic digestion and its capital costs remain limited.

Life Cycle Analysis (LCA)

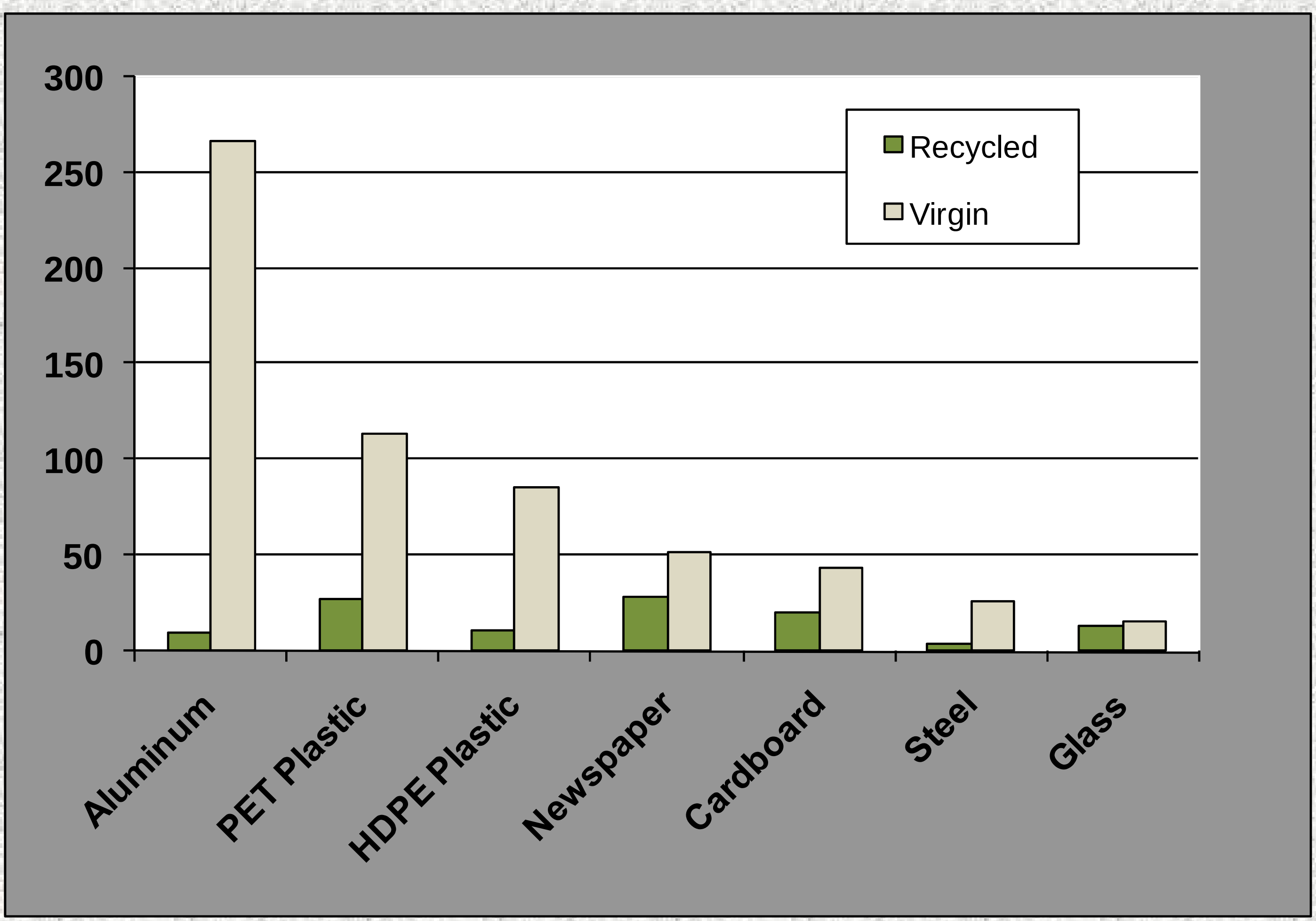


One or limited number of return cycles into product that is then disposed – open-loop recycling. Repeated recycling into same or similar product, keeping material from disposal – closed-loop recycling.

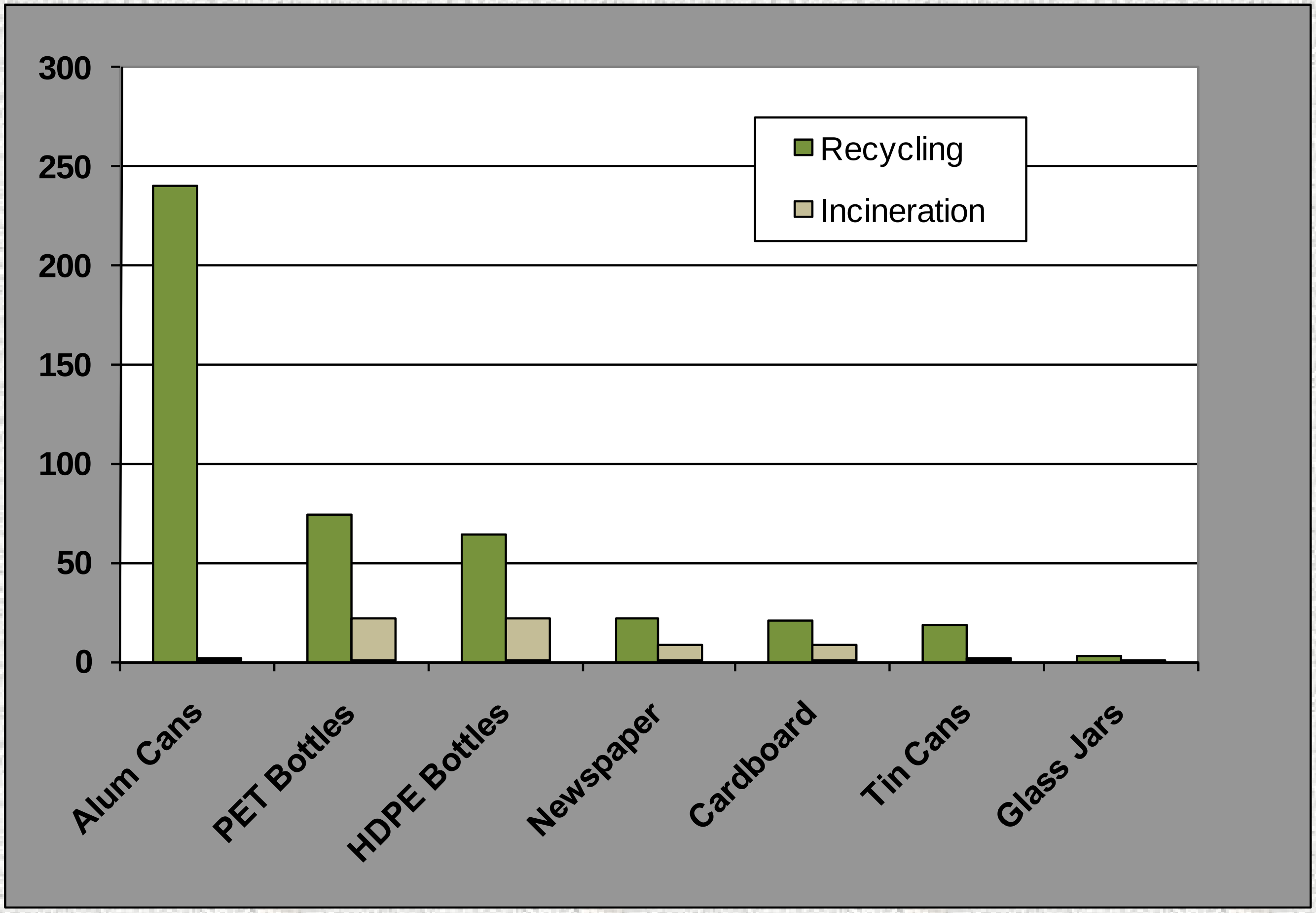
Environmental Impact Model - Data Sources

- US EPA WARM model
- US EPA MSW Decision Support Tool
- Carnegie Mellon University Economic Input-Output Life Cycle Assessment model (www.eiolca.net)
- Washington State Department of Ecology
- Peer-reviewed journal articles

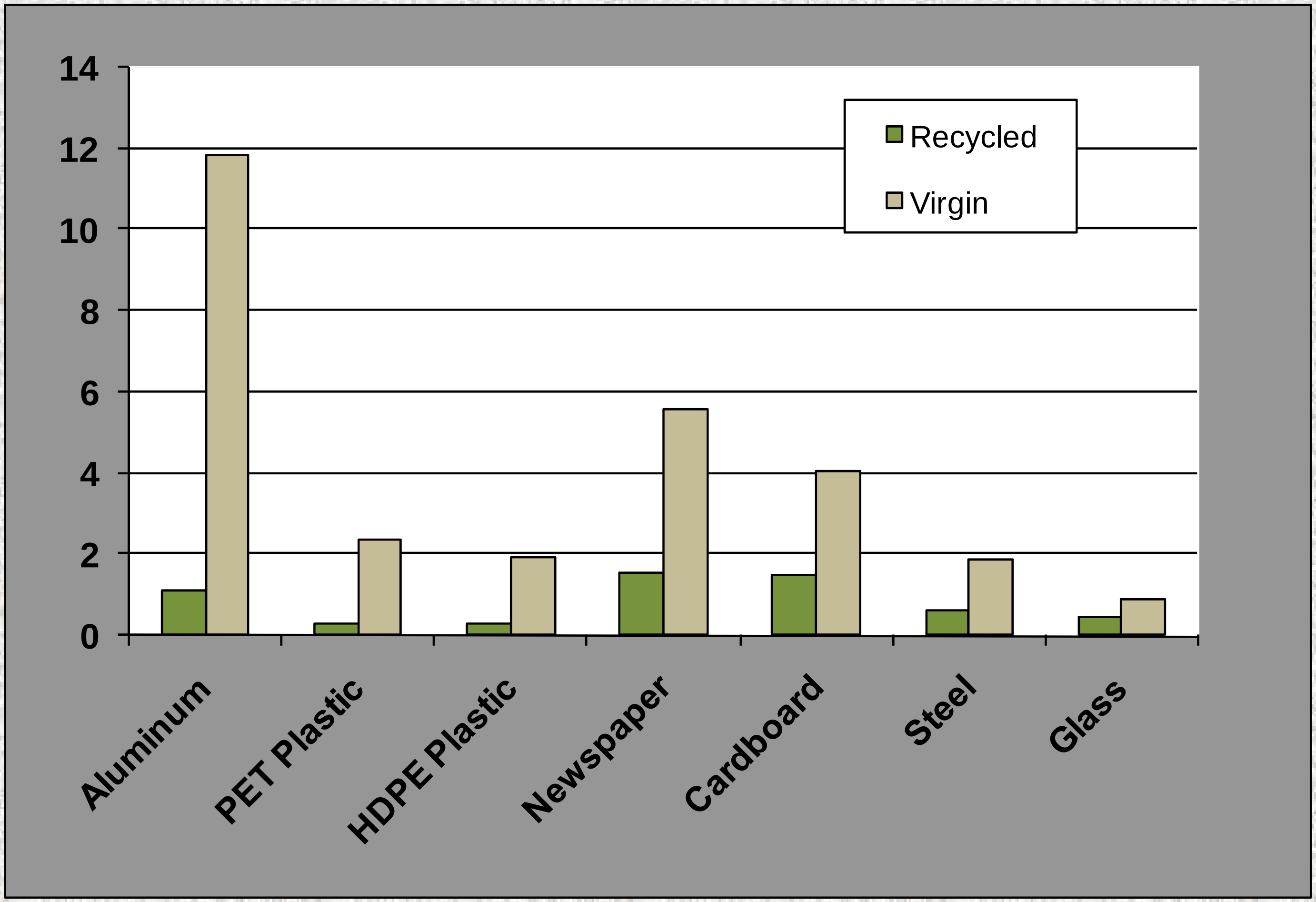
Energy Use: Recycled & Virgin Content Products (MJ/kg)



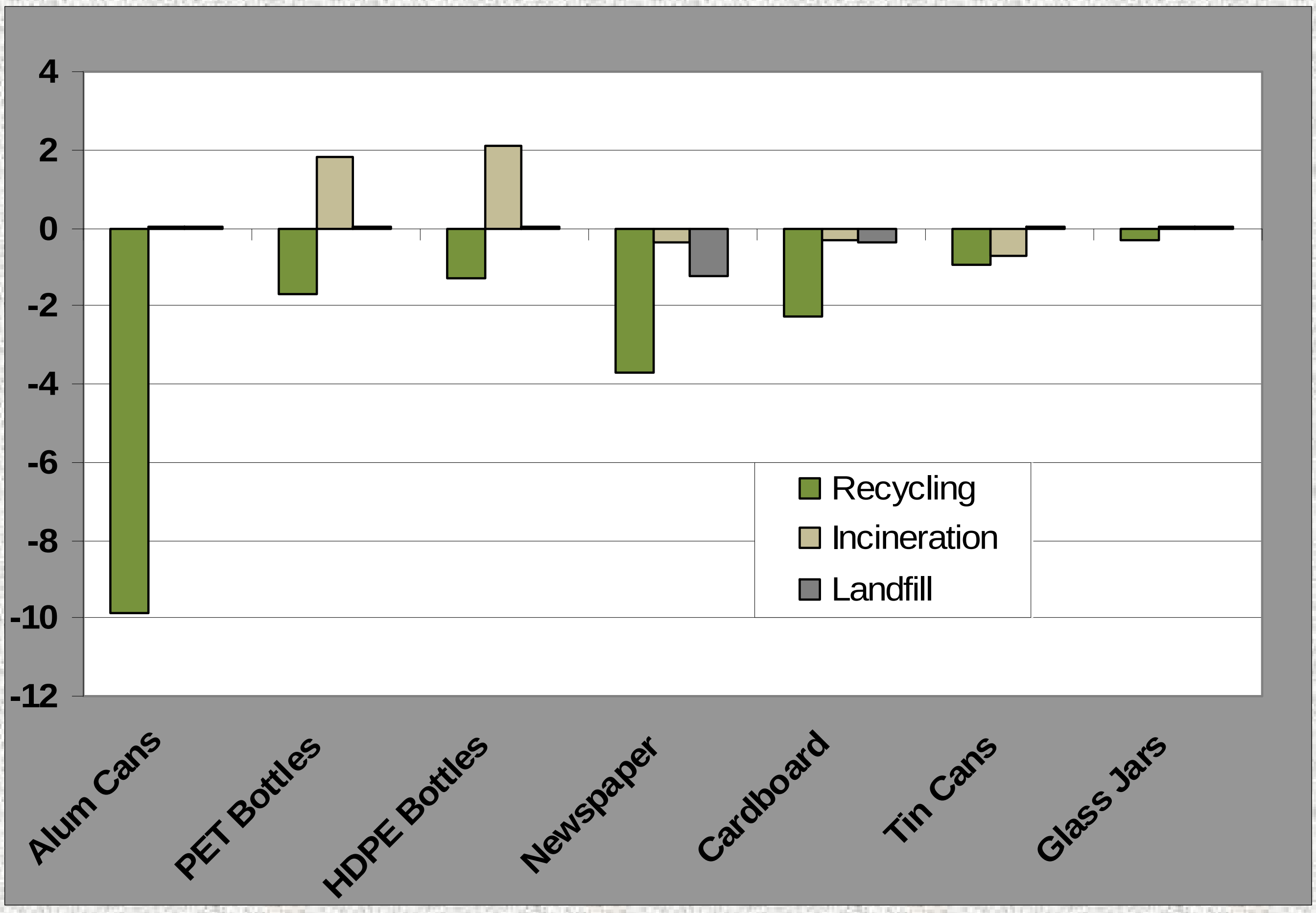
Energy Savings: Recycling versus Incineration (MJ/kg)



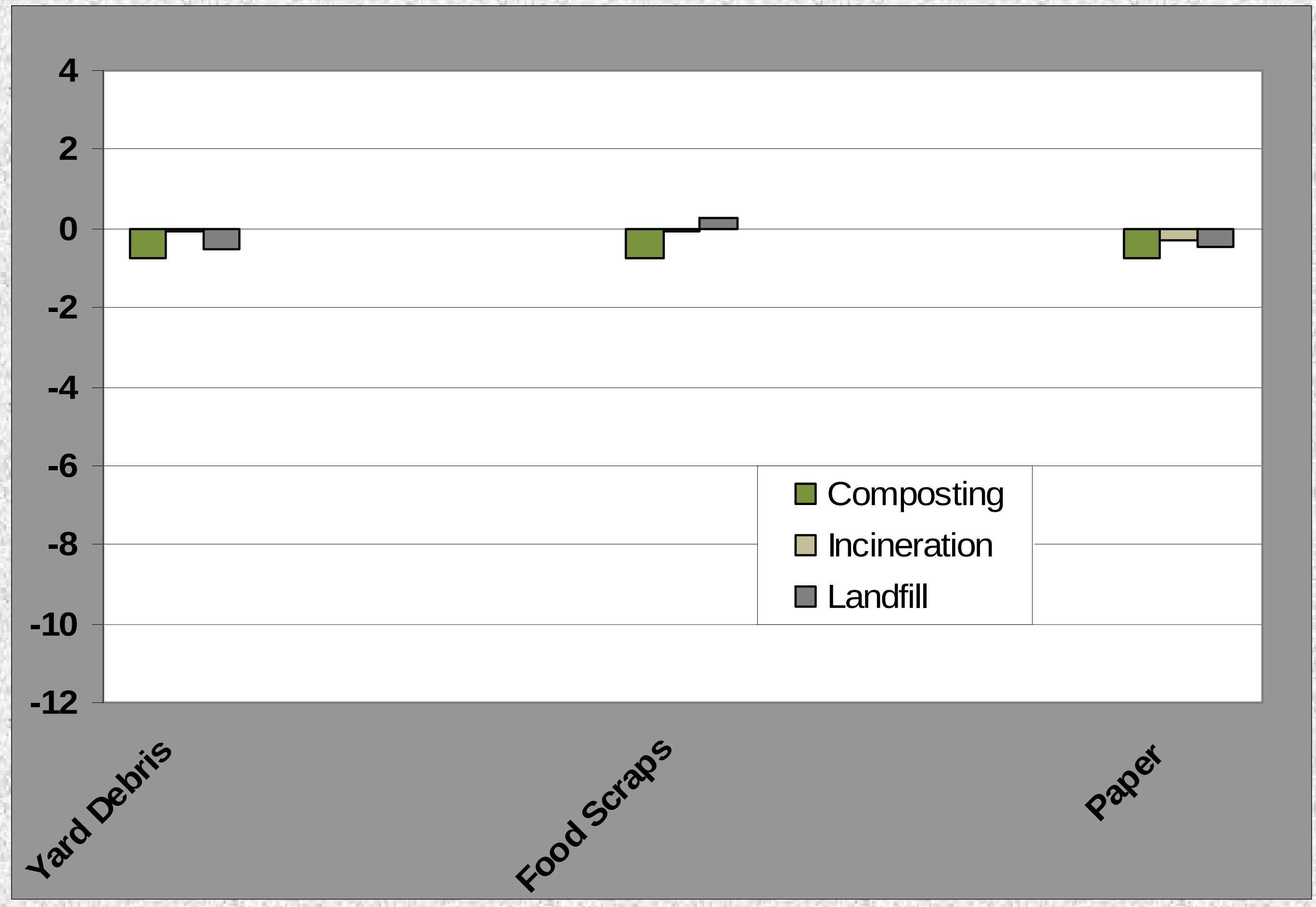
CO2 Emissions: Recycled &Virgin Content Products (kg eCO2 / kg)



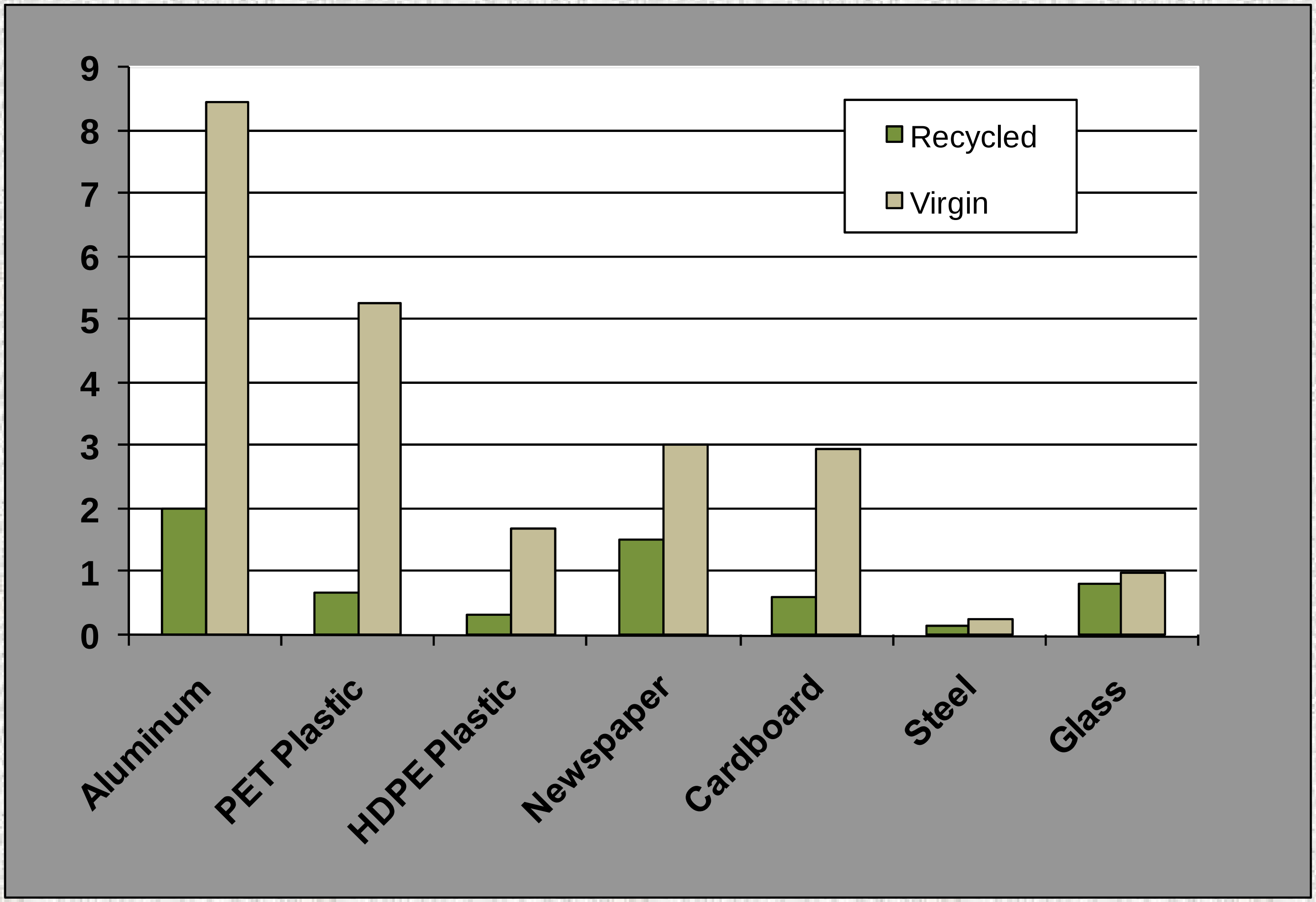
CO2 Emissions: Recycling versus Disposal (kg eCO2 / kg)



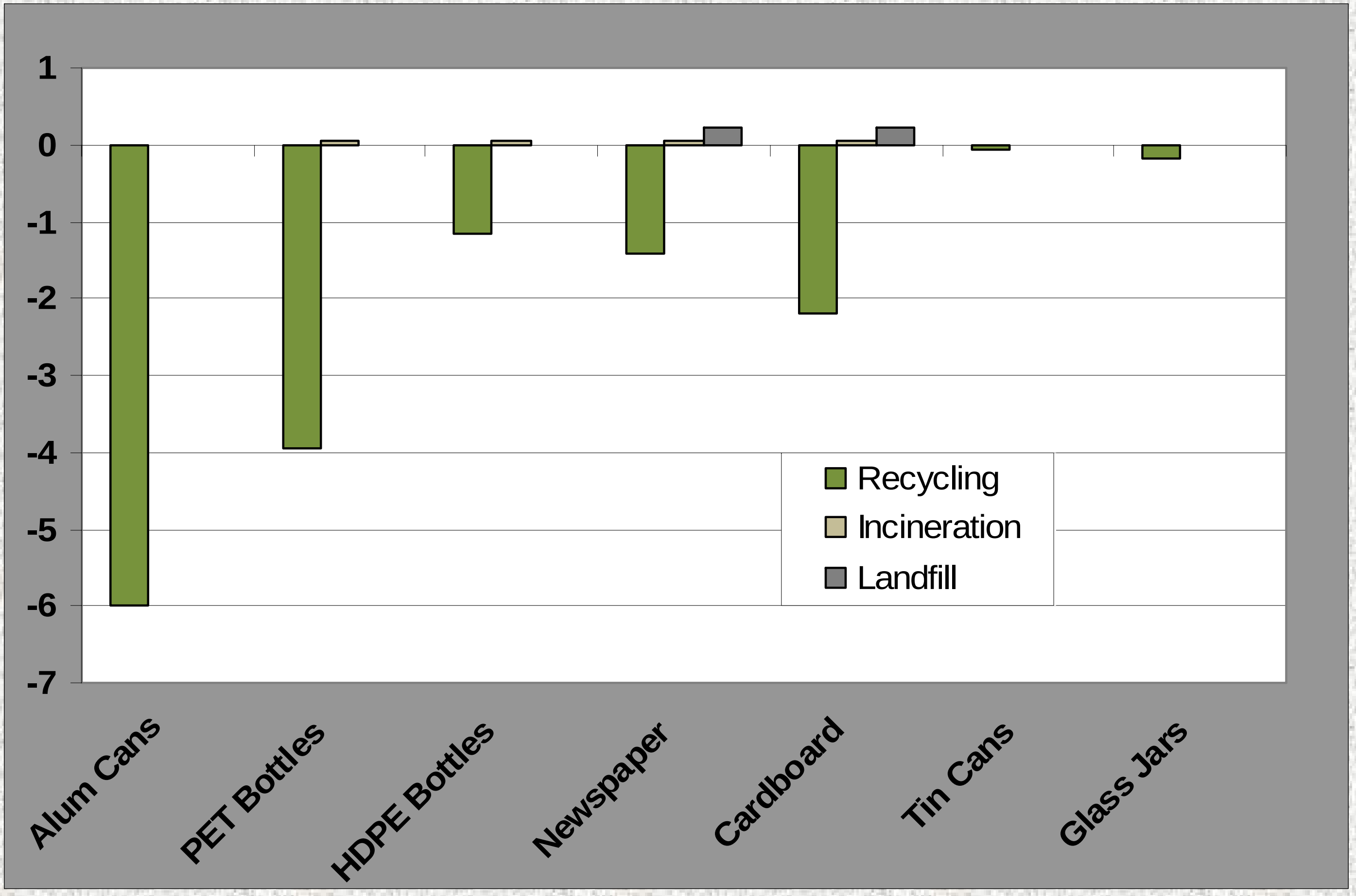
CO2 Emissions: Composting versus Disposal (kg eCO2 / kg)



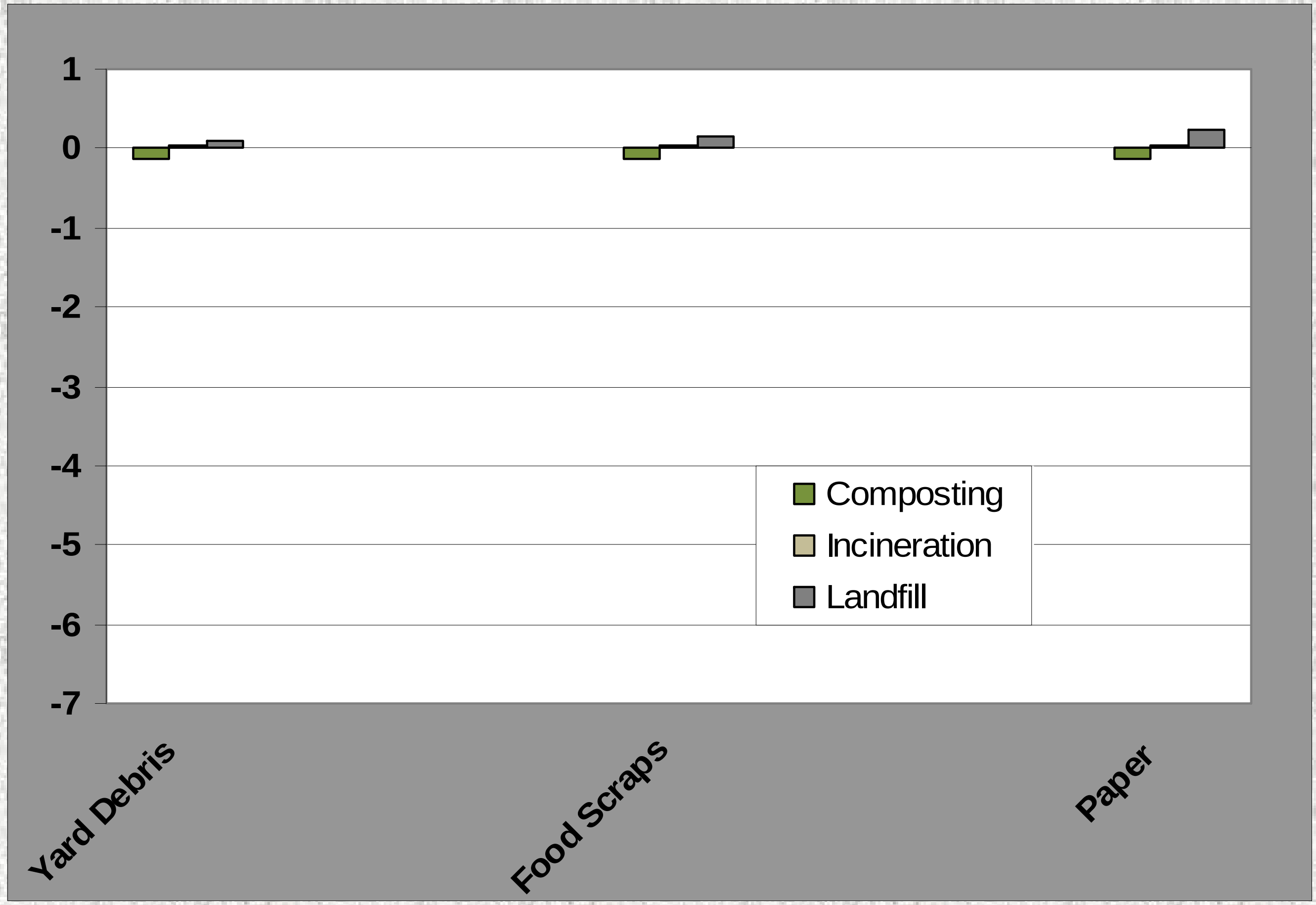
Toxics Emissions: Recycled & Virgin Products (kg eToluene/kg)



Toxics Emissions: Recycling versus Disposal (kg eToluene/kg)



Toxics Emissions: Composting versus Disposal (kg eToluene/kg)



Value of Pollution Reductions

LCA Impact	Economic Cost (US$/ton)
Climate Change	$36 eCO2
Human Health - Particulates	$10,000 ePM2.5
Human Health - Toxins	$118 eToluene
Human Health - Carcinogens	$3,030 eBenzene
Ecosystems Toxics	$3,280 e2,4D
Acidification	$661 eSO2
Eutrophication	$4 eNitrogen e = equivalent

Value of Pollution Reductions from Recycling & Composting

Discard Type	Environmental Value (US$ / metric ton)
Newspapers	$363-367
Cardboard	$467-496
Mixed Paper	$172-197
Glass Containers	$61
PET Plastics	$639-712
HDPE Plastics	$224-310
Other Plastics	$224-310
Aluminum Cans	$1,607
Ferrous Cans & Scrap	$18-72
Food Scraps	$62-107
Yard & Garden Debris	$61-74
Compostable Paper	$52-78

Strategic Approach to Waste Reduction

- Individual waste prevention programs should be integrated in a coherent overall strategy to maximize effectiveness
- Sustainable consumption initiatives, such as those underway in Europe, offer significant waste prevention potential
- Focus on priority materials and/or sectors
- Economic instruments such as taxes or fees should be part of the mix
- Measuring effectiveness of waste prevention programs is challenging but important
- Government partnerships with the private sector, NGOs and other stakeholders are critical for success

Waste Reduction Methods/Tools

- **How We Make Things: Productivity Improvements**
  - P2, lean manufacturing, industrial ecology, green permits, and technological advances: light-weighting, miniaturization and dematerialization, micro- and nano-technology
- **How We Do Business: Alternative Models**
  - Design for Environment (DfE) programs
  - Supply chain management
  - Leasing and "servicizing"
- **Public Awareness and Action**
  - Consumer demand for more environmentally friendly products
  - Emerging sustainable lifestyle movement, including the simplicity movement
  - Community-Based Social Marketing
- **Economic Incentives**
  - Packaging tax, pre-disposal fees, point-of-sale levies
  - Pay-As-You-Throw for municipal (residential) sector
  - Resource Management contracting for business sector
- **Regulatory Requirements**
  - Product Stewardship / Extended Producer Responsibility (EPR)
  - Waste bans
- **Government Leadership by Example**
  - Environmentally Preferred Procurement/Purchasing (EPP)
  - Internal practices such as duplex copying, equipment reuse, green building

Waste Reduction Best Practices

Production

- Resource Productivity Improvements
  - Pollution prevention (P2)
  - Lean manufacturing
  - Green permitting
  - Industrial ecology
  - Technological advances: light-weighting, miniaturization and dematerialization, micro- and nano-technology

- Alternative Business Models
  - Promoting Design for Environment (DfE)
  - Supply chain management
  - Product stewardship
  - Leasing and "servicizing"

Waste Reduction Best Practices

Distribution

- Packaging tax, pre-disposal fees, point-of-sale levies
  - Minimize packaging
  - Reusable packaging/shipping containers
- Packaging ordinances
- Extended Producer Responsibility (EPR)
- Supply chain management

Waste Reduction Best Practices

Retail

- Minimize packaging
- Leasing and “servicizing”
- Product stewardship/
  Extended Producer Responsibility (EPR)
- EPP and supply chain management
- Resource Management contracting

Waste Reduction Best Practices

Consumption

- Environmentally Preferable Purchasing (EPP)
- Public Awareness and Action
  - Consumer education regarding waste prevention
  - Emerging sustainable lifestyle movement, including the simplicity movement
  - Community-Based Social Marketing
- Pay-As-You-Throw for municipal (residential) sector